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STUDIES IN RASPBERRY DISEASES

MOSAIC, LEAF CURL, ROSETTE AND WILT

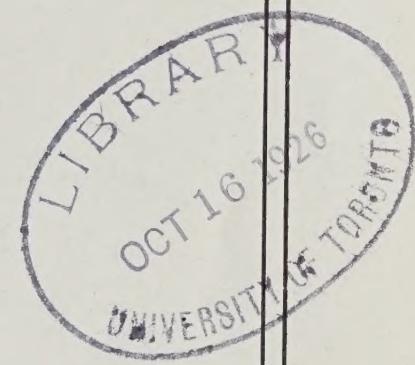
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TABLE OF CONTENTS

	PAGE
Mosaic and leaf curl..	3
Resette, or bramble streak of black raspberry..	10
Verticillium wilt..	10

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Letters addressed to the Dominion Botanist at Ottawa may be sent free by mail; also specimens in parcels not exceeding twelve ounces in weight.

MOSAIC, LEAF CURL, ROSETTE, AND WILT OF THE RASPBERRY

BY

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MOSAIC AND LEAF CURL

During the last five years the growers of raspberries have been confronted with a rapid "running out" of their plantations. In some sections this has been of so severe a nature that certain red varieties have been discarded by the grower as unprofitable.

In 1921 Dr. W. H. Rankin, who was then officer-in-charge of the Dominion Laboratory of Plant Pathology, St. Catharines, started an investigation into this so-called "running out" and soon ascertained that it was due mainly to two diseases, "mosaic" and leaf curl"¹. The nature of these diseases is not yet fully understood. No definite organism has been isolated or found associated with them. Both mosaic and leaf curl are of the virus type, are infectious and are readily spread from plant to plant by means of plant-lice or aphids. Once a plant is infected it is only a matter of time until the whole plant becomes devitalized, dwarfed and unprofitable. The infectious principle is in the plant juices or sap.

HISTORY

These diseases have been known for some twenty-five years. Until quite recently they were generally considered as one, under the term "yellows", on account of its similarity to peach yellows. In 1921, however, it was clearly demonstrated by Rankin that those abnormalities of the raspberry which had been commonly referred to as "yellows" were in reality due to two distinct diseases of the virus type and he suggested the terms "mosaic" and "leaf curl" as being suitable. These terms are in general use to-day.

DISTRIBUTION

Mosaic is found throughout Canada on wild and cultivated varieties. In Ontario it is now general on red, purple and black varieties. In the Niagara peninsula and eastward along the northern shore of lake Ontario it is particularly severe, many Cuthbert plantings showing 100 per cent infection with the average around 15 per cent or 20 per cent. In the London and Waterford districts the average percentage of infection is around 3 per cent. In Quebec the Cuthbert shows infection up to 30 per cent. In Saskatchewan the Sunbeam, Herbert, King, Ohta, and Miller have been reported as infected. In the Maritime Provinces the Herbert and Cuthbert have been reported as severely infected in some cases. In Manitoba, Alberta, and British Columbia reports indicate that mosaic is prevalent on certain varieties.

Leaf curl is not so general in its distribution as mosaic but is severe in certain localities.

¹ Report of Dominion Botanist for year ending March 31, 1922.
23914-1½

SYMPTOMS

MOSAIC.—Mosaic symptoms are to be found on the leaves, and leaves only. The leaves do not dry up, wilt or fall, but rather take on a somewhat lighter colour than the normal green of a healthy plant. As the disease progresses the leaves become mottled and dwarfed. This fine to coarse yellowish-green mottling (Fig. 1) is very faint in newly infected plants, but later becomes very distinct and the light-yellowish patches between the normal green of the leaf are very pronounced. The ratio between light-yellow and green varies greatly so that sometimes the dark-green spots are more numerous than the light-yellow and vice versa. In either case the characteristic symptom is that the normal green of the leaf gives place to light-yellow areas of varying size, giving the leaf surface a mottled appearance. Accompanying this mottling is generally a puckering or roughening of the leaf surface. This is particularly true of certain

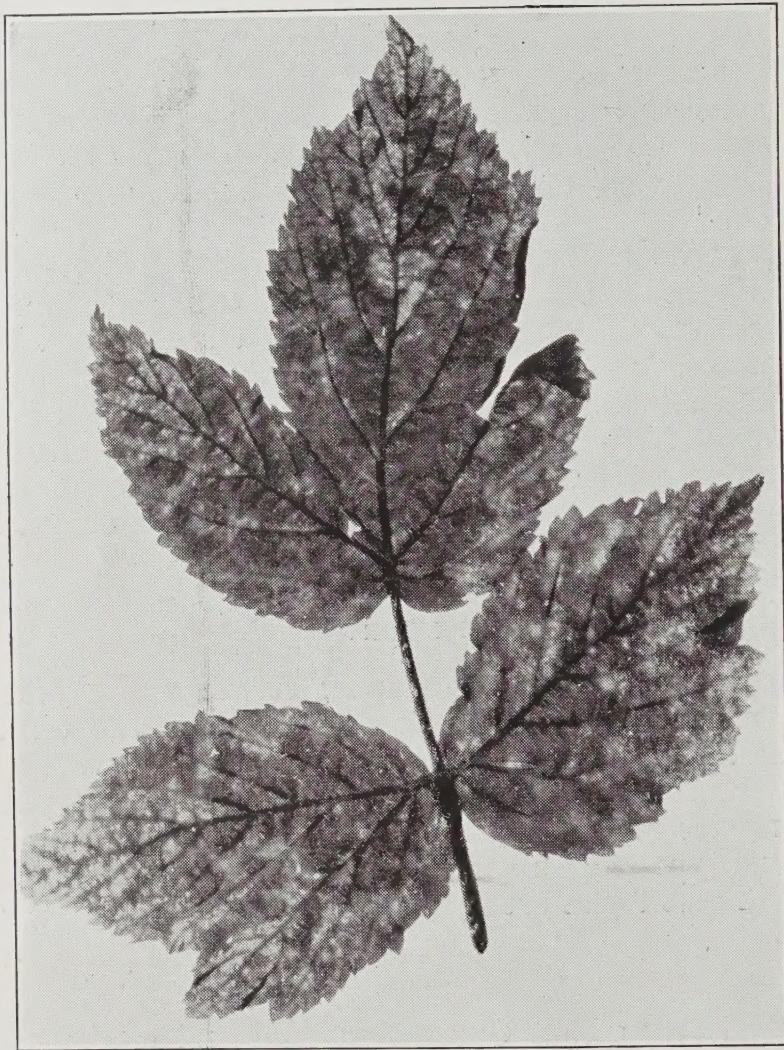


FIG. 1.—Cuthbert leaf showing the characteristic mosaic mottling.

varieties such as the Columbian. The dark-green spots are generally raised above the mean surface of the leaf, resulting in a dull, uneven surface in contradistinction to the smooth, shiny, even surface of a normal leaf. One constant sign for identification purposes is that when a leaf on a shoot becomes mottled all the new foliage produced on that shoot develops the same characteristic mottling.

Mosaic symptoms as outlined are particularly noticeable on new growth, especially the suckers. In the early summer this is where the first signs of mosaic are apparent, and in making an inspection of a plantation look always on the present season's growth. Inspections should start about the first of June, and be repeated at intervals throughout the growing season. When inspecting

your raspberries for the presence of mosaic walk down a row of raspberries, casting your shadow on the plants under observation, because under these conditions (shade) mosaic symptoms show up better on a very bright day. Great care must be taken with the inspection since the mosaic mottling in its early stages is easily overlooked on account of its indistinctness, and since success in control, from the roguing standpoint, depends almost entirely on taking out mosaic plants as soon as they become diseased, the value of careful and efficient inspection is apparent.

The symptoms on the different varieties vary somewhat. The mottling on all varieties when newly infected is rather indistinct. On Cuthbert, King and Newman 23, the mottling is generally fine, whereas with the Herbert, Marlboro and Viking varieties the mottling is often very coarse. Sometimes however, the Marlboro has a very fine indistinct mottling that is hard to diagnose.



FIG. 2.—Dwarfed mosaic (left) and healthy bush (right). Note also puckering and slight curling of the lower leaves on the mosaic bush.

There may be very little dwarfing noticeable the first year of infection, but thereafter dwarfing becomes gradually more pronounced each year (Fig. 2). The fruit from dwarfed mosaic bushes is greatly reduced in quantity and the berries are mostly soft, crumbly, and insipid.

LEAF CURL.—As with mosaic, so with leaf curl, the symptoms of the disease are confined to the leaves. The leaves in this case are not mottled however, but are abnormally dark-green in colour and are wrinkled and curled. The curling

on newly infected plants may be very slight but later the entire margin of the leaf becomes rolled downward and inward (Fig. 3). The fruiting laterals are short and usually stand upright. The suckers from a diseased bush of a previous year are dwarfed and terminate in a yellowish stunted tip. The fruit is dry and seedy and is not worth picking. Once a bush has become diseased, it is not only useless from the standpoint of production, but in addition is a source of constant spread of infection to nearby healthy bushes.



FIG. 3.—Healthy plant (left) and leaf curl plant (right). Note rolling inward and downward of leaf surface.

SUSCEPTIBLE VARIETIES

The following varieties are known to be susceptible to mosaic:—

Abundance, Brighton, Brilliant, Columbian, Count, *Cuthbert, Cumberland, Dr. Reider, Eaton, Empire, Golden Queen, Gregg, Haymaker, *Herbert, Highland Hardy, Idaho, June, King, Lonboro, Latham, Marlative, *Marlboro, Marldon, Minnesota, Miller, Newman 1, Newman 23, Newman 24, Ontario, Ohta, Plum Farmer, Royal Purple, Ruby, Segrist, Seneca, St. Regis, Sunbeam, Shaffer, Syracuse, Perfection, Belle de Fontenay, Redpath, Viking, *Erskin Park.

The writers know of no resistant or immune variety that can be recommended at the present time for commercial propagation. They have however,

* Susceptible to leaf curl as well.

under observation, a new red raspberry seedling, Adams 87, originated by Mr. Geo. Adams, Smithville, which has great promise of being highly resistant if not immune. This berry is not yet on the market.

RATE OF SPREAD

In Ontario the annual spread of mosaic is not rapid. From demonstration and experimental plots, as well as in fruiting plantations, we have found the average yearly spread for the last three years to be around 4 per cent. This is not rapid but is rather a slow but constant, unobserved spread that eventually succeeds in devitalizing the plantation; a case of the tortoise "slow but sure". In New York State, particularly in the Hudson river valley, spread in 1924 was reported up to 80 per cent. In general throughout New York State it is considerably greater than in Ontario.

Leaf curl in the Niagara peninsula is now considered of minor importance, since the growers have been systematically roguing this disease for the past few years. There is therefore little leaf curl present and hence spread is likewise small. In districts however where strict attention is not paid to this disease the spread will be as great if not greater than mosaic.

MANNER OF DISSEMINATION

Observation and research has shown that both mosaic and leaf curl are spread by means of aphids, commonly called plant-lice. That these insects are one of the agents which spread the mosaic and leaf curl diseases is entirely due to their feeding habits. They are sucking insects and while passing from diseased to healthy bush in the course of feeding, they transmit the contagious principle which is contained in the plant juices. Rankin and others have shown that *Aphis rubiphila* is able to transfer the leaf curl disease. It has been thought for some time that this same species, on account of its being the most common aphid of the raspberry, was the means of spreading the mosaic disease as well. However, recent unpublished work by C. W. Bennet of Michigan State College has shown that another species of aphids, *Amphorophora rubi*, is responsible for mosaic spread. Field observation would tend to bear this out, because in Ontario where spread is slow, few *Amphorophora rubi* are present. In New York State where *Amphorophora rubi* is much more abundant, rate of mosaic spread is also greater, while in the Hudson river valley where the species *Amphorophora rubi* was very abundant in 1924 the greatest spread (up to 80 per cent) was reported in that year.

Since all parts of a mosaic or leaf curl plant contain the infectious principle, these diseases may also be spread by means of vegetative shoots (suckers, tips, root-cuttings), from diseased plants. It is for this reason that the use of healthy certified stock for planting purposes is so highly recommended.

ECONOMIC IMPORTANCE

It has already been pointed out that the so-called "running-out" of certain raspberry varieties is largely, if not entirely, due to mosaic, leaf curl, and similar diseases. Such being the case it is at once apparent that mosaic and leaf curl are a serious menace to the profitable growing of raspberries in Canada.

In an experimental plot of thirty mosaic and thirty healthy bushes the total crop harvested in 1925 from healthy bushes was 24,517 berries, and from diseased bushes, 18,664 berries—a reduction in yield of 5,853 berries.

If this substantial loss from thirty bushes was sustained as a result of mosaic the loss in an acre plantation must be considerable. In dollars and cents, it would be somewhere between \$150 and \$200 per acre. In this con-

nection it must be pointed out that these bushes were only two years old. In older plantations the loss per mosaic plant would be still greater due to the cumulative devitalizing effect of mosaic on a raspberry plant.

According to our leading horticulturists² the yield per acre from well cared for, healthy red raspberries should be, in a favourable season, from 4,000 to 7,000 quart boxes. Yields as high as 8,000 boxes per acre have been reported. Yet how many growers to-day are getting anything like this crop per acre? What is the reason for the low yields of to-day? "Mosaic and leaf curl", is largely the answer.

Generally speaking, plantations that contain considerable mosaic are by no means as productive as they should be. Since a bush once infected with mosaic or leaf curl, never recovers and in addition since all such bushes left in the plantation become sources for increased infection and spread, the effect of these diseases upon the raspberry-growing industry is apparent. These two diseases therefore deserve the careful attention of every grower since they are without doubt the worst diseases of the raspberry and cause an annual loss of many thousands of dollars.

CONTROL

With infectious diseases of this type the first essential in control is a knowledge of the symptoms, etc., so that a grower may be enabled to diagnose the disease in the field. Success in mosaic and leaf curl control largely lies in the ability to identify these diseases in the young plantation and to rogue thoroughly.

In order that the raspberry-growers of Ontario may become familiar with these diseases and the methods of control, the Dominion Laboratory of Plant Pathology at St. Catharines maintains an inspection service, through which this information is given free to the grower upon request.

Before giving the actual methods for control it will be well at this point to recapitulate the following facts upon which the control measures are based.

- (1) Once a plant becomes infected, it never recovers.
- (2) All parts of the plant carry the infectious principle.
- (3) The mosaic symptoms are rather hard to diagnose.
- (4) Spread is brought about by plant-lice and vegetative parts such as suckers, tips, or root-cuttings.
- (5) These diseases are not carried in the soil provided roots of diseased bushes have been completely removed.

Bearing these facts in mind the reasons for the following control measures become at once apparent.

NEW PLANTINGS.—The most permanent and satisfactory control measures for mosaic and leaf curl begin with the setting out of healthy certified raspberry stock. Such stock has now been available in Ontario for the past three years as a result of the raspberry inspection and certification service carried on by the Dominion Laboratory at St. Catharines. Experiments with this stock have shown it to be in all respects satisfactory. Where such stock has been set out and has been carefully inspected, and diseased bushes rogued during the growing season, it has been found after three years' experience, that only a fraction of one per cent is now present. In many such plantations no more than 20 or 25 plants have had to be rogued during the past two years. Of course where roguing has not been done, mosaic has increased to a much greater extent. Therefore in setting out a new plantation use only healthy certified stock. *Never use doubtful stock from a neighbour's plantings just because it costs you nothing. It is false economy.* This has been demonstrated time and time again. For

² Bush Fruits—Bull. 94, p. 29. Dom. Dept. of Agr.

example: the average commercial plantation started from other than certified stock will have at least about 5 per cent mosaic to start with. This is a very conservative figure because many such plantations have in their first year 20 per cent and 25 per cent, and we have found a few that were 100 per cent infected with mosaic and leaf curl. In five such plantations the following average increase of mosaic has been recorded.

1923	4.0 per cent.
1924	12.5 per cent.
1925	24.0 per cent.

On the other hand, the average increase in seven plantations where certified stock was used, was as follows:—

1923	0.5 per cent.
1924	0.75 per cent.
1925	1.30 per cent.

The highest percentage of mosaic found in a plantation of certified stock after three years was 4 per cent (no roguing in this case) while in some the amount of mosaic actually decreased due to careful roguing.

Our experience with these diseases demonstrates that although certified stock is the *first* essential in control, the roguing of diseased bushes during the first two seasons at least should by no means be neglected. Roguing has proved to be a valuable aid in mosaic control and we therefore strongly recommend its use in all plantings up to three years of age that contain a small amount of mosaic. This is particularly true for plantations, set out with certified stock, where only a trace of mosaic will creep in the first year.

Therefore during the first season the young plantation should be carefully and systematically inspected several times by the grower and all diseased plants should be dug out, roots and all, and removed immediately from the plantation before the foliage has had time to wilt. If the bushes are allowed to wilt before removing, the aphids will have had a chance to pass from the wilted leaves to nearby healthy leaves and thus in place of effecting control, spread has actually taken place. In the removing of the bushes great care should be taken to see that the diseased bushes are not dragged along the ground, or allowed to brush healthy plants, since the aphids which are feeding on the diseased plants, may be then knocked off and left to infect healthy bushes.

During following seasons it is absolutely essential to continue careful inspections and roguing. Constant vigilance will be necessary to keep the patch free from disease. However, three years' experience has demonstrated that it can be done satisfactorily and with very little labour, provided the planting is started with certified stock.

OLD PLANTATIONS.—An old plantation containing a considerable amount of mosaic should be ploughed up, or possibly let run until a new planting comes into bearing. It is not advisable to attempt to rogue a plantation over two years of age that has more than 5 per cent mosaic. A two-year-old plantation that has a small percentage of mosaic, may be put in a fairly healthy condition by careful and continued roguing.

In roguing (unless the bushes have just recently been set out, and are therefore some considerable distance apart in the row) it is advisable to rogue the healthy bush on either side of the mosaic in order that this apparently healthy bush may not act as a bridge to pass on the infectious principle to the next adjacent bush. Experience has repeatedly demonstrated the advisability of so doing. Rogued bushes should be carried carefully outside the plantation and burned.

Gaps, the result of roguing, may be reset with healthy stock at any time, provided all roots of the previous diseased bush have been removed. If such roots have not been removed, suckers will spring up therefrom which may infect the healthy reset.

The hill system of planting is to be highly recommended as a cultural aid in controlling mosaic, because if the plants are kept in hills there will be less touching and interlocking of adjacent plant parts than in the hedge-row system, and spread will thereby be rendered more difficult. The bushes, however, must be spaced sufficiently far apart to allow of easy access of horse and cultivator in order that the aphids may not be displaced and spread by the rubbing and jarring of the foliage. Also in the hill system the disease may be more easily detected and an entire hill may be eliminated with much greater ease and satisfaction than is possible with a section of the same size in a hedge-row.

New plantings of healthy stock should be isolated at least 300 feet from nearby wild or cultivated raspberries.

ROSETTE, OR BRAMBLE STREAK OF THE BLACK RASPBERRY

This is an infectious disease similar in many respects to mosaic and leaf curl, but found only on black raspberries. This disease has been extremely severe in the Eastern and Middle Western States, but thus far the writers have observed but two plantations in Ontario. During inspections around Brockville in 1925 a small plantation of black raspberries was found badly affected with this trouble. The bushes were stunted. The leaves of diseased plants were slightly curled, and were crowded very closely together giving a rosette appearance. The leaves were very faintly mottled as with mosaic. No pronounced discoloration or spots were noticeable on the stems, as is often associated with this disease in the Eastern States. In 1926 a plantation was found at St. Catharines, which was severely attacked by this disease.

CONTROL

The same control measures as outlined for mosaic and leaf curl, apply here.

The Dominion Laboratory of Plant Pathology, St. Catharines, would be very glad to receive from raspberry growers, any reports of the suspected presence of this disease on black raspberries.

VERTICILLIUM WILT

Caused by *Verticillium ovatum*, Berkeley & Jackson

The diseases previously described (mosaic, leaf curl, and rosette) are all of the physiological or virus type, the cause of which is not definitely known, whereas "wilt" is a fungous disease caused by *Verticillium ovatum*, Berkeley & Jackson.

In 1923 this disease was reported by the authors³ on red raspberries, under the title "Blue Stem of the Red Raspberry." It is now considered advisable to use the term "wilt" since "blue stem" is the term commonly applied to a disease of raspberries of the virus type, known as Eastern Blue Stem, or Rosette. Moreover, since the striking characteristic of this disease is a yellowing, drooping, and "wilting" of the leaves, it seems more appropriate to use the term "wilt."

³ First reported by the authors at annual meeting of Canadian Phytopathological Society held at Queen's University, Kingston, 1923 and later appeared as an abstract in phytopathology, vol. 14, p. 347, 1924.

This disease has been found throughout Ontario during the past three summers on the following varieties:—

Red raspberry—

Cuthbert
St. Regis
Marlboro
Viking
Herbert

Black raspberry—

Cumberland
Gregg
Plum Farmer

Other varieties are likely to be equally susceptible; this has, however, not yet been determined, largely due to their being so little grown in Ontario.

During 1923 several plantings of black raspberries were observed which had around 40 per cent infection. Red plantings this same year showed as high as 20 per cent infection. In 1924 and 1925 the disease was not so severe on red varieties although about the same on black varieties.

On black raspberries "wilt" is particularly severe; the authors have seen several cases where it was present to such an extent that it was considered advisable to discard the plantation. On red raspberries the disease does not appear to be so severe, yet cases have been observed where great damage was done and since "wilt" is now present throughout Ontario it would seem to be good policy for every grower to get familiar with this comparatively new disease.

SYMPTOMS

RED RASPBERRIES—The disease first becomes apparent in the field by a yellowing and wilting of the lower leaves. These leaves then droop and fall. (Fig. 4). This wilting and casting of the leaves progresses from the ground upwards. As a result the cane finally becomes devoid of leaves, with the possible exception of a tuft of small brownish leaves at the extreme tip. This tuft of terminal leaves sometimes adheres for a considerable period. (Fig. 5.)

Generally accompanying this wilting and casting of the leaves is a blue discoloration of the cane, hence its former name: "blue stem." This discoloration may be present as stripes starting from about the ground line and closely following the upward progress of defoliation, or the discoloration may cover the entire circumference of the cane. Canes have been observed with continuous stripes up one side, or both sides, or completely girdled by the blue discoloration. On the other hand numerous diseased canes have been observed which have shown no signs whatever of the blue discoloration, although they had been defoliated for some time. The blue discoloration although generally present, may be wanting. The important, striking and constant symptom is therefore a yellowing, wilting and casting of the leaves.

In late fall and winter the presence of wilt may be ascertained by the presence of dead canes. Of course, all dead canes are not necessarily due to "wilt," but in a plantation where "wilt" has been prevalent dead canes are plentiful. Canes that have gone into the winter condition apparently healthy although recently infected with this disease may be (1) killed, so that the buds will not unfold in the spring, (2) may be partially killed, so that only the buds on certain sections will unfold, or (3) may leaf out quite normally in which case the leaves and laterals are dwarfed and any fruit formed is small and tasteless. More often such canes lose their leaves and die before fruiting time.

BLACK RASPBERRIES—On black raspberries the disease is much the same as described for red varieties with the exception that the blue discoloration is more pronounced, and generally girdles the cane. Sometimes the first indication is a premature drying of the fruit. Black varieties are much more susceptible to this disease, and a plantation of such varieties more readily succumbs than the red variety due no doubt in part to the fact that the black



FIG. 4.—Early stage of wilt. Note the curled and wilted leaves.

varieties do not sucker. That is, once a black variety takes this disease, since it is a root as well as shoot disease, the plant as a whole becomes infected and is eventually killed. In suckering varieties, however, new shoots may be sent up some little distance away from the parent plant, which therefore may escape infection, at any rate for a time. That such is actually the case has been observed quite commonly in the field.

DISTRIBUTION

Cases have been noted where every cane in a hill was diseased and where eventually the whole hill was killed. With the black varieties this is generally the final result of infection, but with the red varieties it is rather unusual. In general the disease on red varieties is not so severe and although some, or all of the canes may be killed, new shoots arise from the underground roots that escape infection.



FIG. 5.—Later stage of wilt, showing almost complete defoliation.

In 1923 three large plantings of red varieties had as high as 20 per cent infection. In 1924 and 1925 only a trace of wilt could be found, although the grower made no effort whatever to effect control. However, considerable financial loss resulted from (1) the loss of crop from fruiting canes of the current year, (2) the reduction of fruiting canes for the next year, and (3) in a general lessening of the vitality of the bushes making them more susceptible to winter injury and other diseases.

In other cases the disease has been present more or less each year. In general, however, it appears that "wilt" is more severe on plantations up to four years of age.

Since "wilt" is now found throughout Ontario on black and red varieties, causing considerable yearly loss and moreover since the disease appears to be on the increase, all growers are advised to get familiar with it.

A FUNGOUS DISEASE

This "wilt" of raspberries is caused by a fungus known as *Verticillium ovatum*, Berkeley and Jackson⁴, which belongs to a group of fungi usually associated with the wilting of many different plants and generally found in the soil. It is thought that the fungus first gains an entrance to the plant by way of the rootlets or root-hairs, and then grows upward into the canes, laterals and petioles, directly clogging the water-conducting cells and materially affecting the flow of water in the plant; and wilting results. (Fig. 6).



FIG. 6.—A cross-section of a piece of raspberry cane, showing the mycelium (the thread-like strands in the open spaces) clogging the wood vessels.

CONTROL

Since this is a comparatively new disease, very little is known as yet concerning definite control measures. However, from our present knowledge of the fungus causing this disease, we would strongly advise as follows:—

⁴ *Verticillium Wilt of the Red Raspberry*—Berkeley, G. H., and Jackson, A. B., in "Scientific Agriculture," Vol. 6, No. 8, April, 1926.

(1) Set out healthy, certified stock⁵ that has come from plantations free of this and other diseases.

(2) Do not set such plantings into soil that has just previously been planted to potatoes, tomatoes, or egg-plants (particularly if these crops showed any signs whatever of "wilting") because these crops are subject to the same wilt disease as raspberries and therefore if raspberries follow one of these crops, wilt may almost certainly be expected in the new setting. It has been the experience of many growers that under such conditions wilt very often became prevalent in the raspberry plantation. Of course, if the previous crop of potatoes, tomatoes or egg-plants was healthy, then it would be safe to follow with raspberries.

(3) Since the fungus is able to live over in the soil practise a four- or five-year crop-rotation taking into consideration that potatoes, tomatoes and egg-plants are subject to this same disease.

(4) It is not advisable to plant potatoes, tomatoes or egg-plants between rows of raspberries as "wilt" may be thus introduced.

(5) Resistant or immune varieties will probably offer the best means of control.

⁵ For information on certified stock apply to the Dominion Laboratory of Plant Pathology, St. Catharines, Ont.

